

Nest and Larvae of the Neuse River Waterdog, *Necturus lewisi* (Brimley) (Amphibia: Proteidae)

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ABSTRACT. — The first reported nest and hatchling larvae of *Necturus lewisi* were found in Little River (Neuse River drainage), Wake County, North Carolina, on 2 July 1978. Finding an adult male tagged for behavioral studies with ⁶⁰Co wires led to their discovery. The nest was under a flat, granite rock in 1.2 m of water at mid-river. Thirty-two empty egg capsules, and three containing larvae which shortly emerged, were attached to the underside of the rock. The male, found in a depression in the sand-gravel substrate directly beneath the eggs, was apparently in attendance. Autopsy revealed that the male was in good condition with an empty digestive tract. The presence of females of other *Necturus* species in or near nests has been reported, but no males have previously been verified in this situation. The hatchling larvae of *N. lewisi* and *N. maculosus* are alike in color and pattern. However, post-hatchling larvae of *N. lewisi* have a light mid-dorsum and dark sides, while those of *N. maculosus*, as figured and described in the literature, have a dark dorsum bordered on each side by a thin, light, dorsolateral line. *Necturus punctatus* larvae are uniformly gray dorsally and lack striping. The distinctive post-hatchling larva of *N. lewisi* lends added credence to its current recognition as a full species.

INTRODUCTION

Necturus lewisi is a species of waterdog endemic to the Tar and Neuse River drainages of North Carolina. Only one field study of this salamander has been conducted (Fedak 1971). No accounts have been published of its life history, and no descriptions of nesting, courtship and reproduction, or illustrations of larvae, have appeared. Adults and larvae are described in Bishop (1926, 1943), Brimley (1924), Cahn and Shumway (1926), Viosca (1937), and Hecht (1958), but the larva descriptions are varied and contradictory. This paper describes the first discovered nest and provides the first accurate descriptions and illustrations of *N. lewisi* hatchlings and older larvae.

MATERIALS AND METHODS

In November 1977 we began a preliminary study of *N. lewisi* in the Little River, a tributary of the Neuse River in northeastern Wake County.

One purpose was to develop methods of following movements, determining home range, and studying other behavior using radioactive tagging and tracking techniques. Three adults (two females and a male) were trapped in wire and plastic mesh minnow traps at that time, and each was tagged with two ^{60}Co (35-50 mc) wires injected into the tail muscles using methods described by Barbour et al. (1969).

We initially used a Thyac III Model 491 survey meter and scintillation probe to locate animals, but monitoring proved difficult until a more sensitive submersible Model 498 probe was obtained later in the study. The tagged salamanders, which we had not located for three months, were easily detected with this instrument. The nest was discovered in July 1978 while we were checking the location of the tagged male. Three larvae were collected as they hatched from eggs, and four others were captured by dip netting within 5 m of the nest site.

Larvae were preserved in 8 percent buffered formalin within one hour after capture, and measurements, color observations and photographs made within two hours after preservation. Measurements, made with an ocular micrometer, are reported as snout-vent length (SV), measured midventrally from tip of snout to vent pore; total length (TL); head length (HL), from tip of snout to gular fold; head width (HW), at posterior edge of eye socket; and tail width (TW), at widest point.

All specimens obtained in this study are deposited in the lower vertebrate collections of the North Carolina State Museum of Natural History (NCSM). Additional post-hatchling larvae and subadults from various localities in both drainages were loaned by Duke University.

RESULTS

Nest. — On 2 July 1978 a nest and attending male (NCSM 19826; 147.6 mm SV) were found under a flat, granite rock ($36 \times 27 \times 5.5$ cm) in 1.2 m of water near midstream, approximately 2 m from shore. The underlying substrate was sand and fine gravel. Thirty-five egg capsules, 8-9 mm in diameter and each attached by a blunt stalk, were in an area of about 60 cm^2 on the underside of the rock. The rock's entire undersurface was devoid of sessile and other invertebrates and debris. A depression in the substrate, slightly larger than the nest area and about 40 mm deep, apparently had been made and maintained by the male. The depression narrowed and opened at the downstream edge of the rock, the upper edge of which was embedded in the substrate. Water flow at the time was slow, but this area is exposed to strong currents during flooding.

The male made no attempt to leave the nest until the rock was removed. It was collected, preserved within two hours of capture, and autopsied to verify sex and to determine general condition and any ob-

vious effects of the radioactive tags. Prior to preservation the animal was quite active and appeared healthy. Dissection revealed that the upper and lower sections of the digestive tract were empty, indicating that the animal had not eaten recently. The liver appeared normal (compared with other preserved specimens of similar size). The gall bladder was filled with bile. Although no fat was evident the animal was not emaciated. There was no indication of damage or irritation to muscle and skin tissue from the tags.

Thirty-two of the 35 egg capsules found were empty, but three were in the process of hatching and the larvae appeared within one hour. Although we netted for approximately 5 m around the nest, only four additional larvae were collected, all within one meter of the nest site. Large rocks and gravel reduced netting efficiency.

Hatchlings (Fig. 1). — The mean total length of seven newly hatched larvae is 22.8 mm (Table 1). The rounded head is totally unlike the squared, elongate head of the adult and ranged from 3.5 to 3.7 mm ($\bar{x}$ = 3.5) long and 3.0 to 3.1 mm ($\bar{x}$ = 3.0) wide. The eyes are dark and appear to be well formed. The forelegs are well developed, 2.0 to 2.2 mm long, with the three outermost toes complete and the inner toe budlike. The hind legs average 1.5 mm in length, are poorly developed, and are adpressed to the lower tail fin. The tail is finned dorsally and ventrally, with the dorsal fin slightly higher than the ventral and barely present at the tail tip. Tail width in the series ranges from 2.9 to 3.2 mm ($\bar{x}$ = 3.0). Because of the yolk sac the lower body is approximately 25 percent wider than the upper body. The head and dorsum are rather uniform light brown, and the color extends onto the area of the tail musculature. A dark line extends from the nostril through the eye to the gills. Behind each eye and above the dark line is a white, apparently rough, patch, equal to or slightly smaller than the eye. The dorsal melanophores stop abruptly on the side along a line level with the front and rear legs. Scattered melanophores are present on the gills, upper surfaces of the legs, lower jaw, and ventrolateral margins of the head. Melanophore concentrations are greatest in the area of the tail musculature, making the tail slightly darker than the head and trunk. The ventral tail fin is unpigmented, while the dorsal tail fin is clear on the margin with melanophores increasing in number toward the musculature.

Post-hatchling larvae. — Color patterns were observed in 61 preserved *N. lewisi* larvae from the Tar and Neuse drainages and in one live specimen from the Neuse. Accurate description of some was difficult because of varying degrees of fading. However, 48 percent of all specimens (N = 28) between 21 and 41 mm SV have a distinct dark lateral stripe on each side, and 37 percent have a light dorsum with the dark sides not well defined

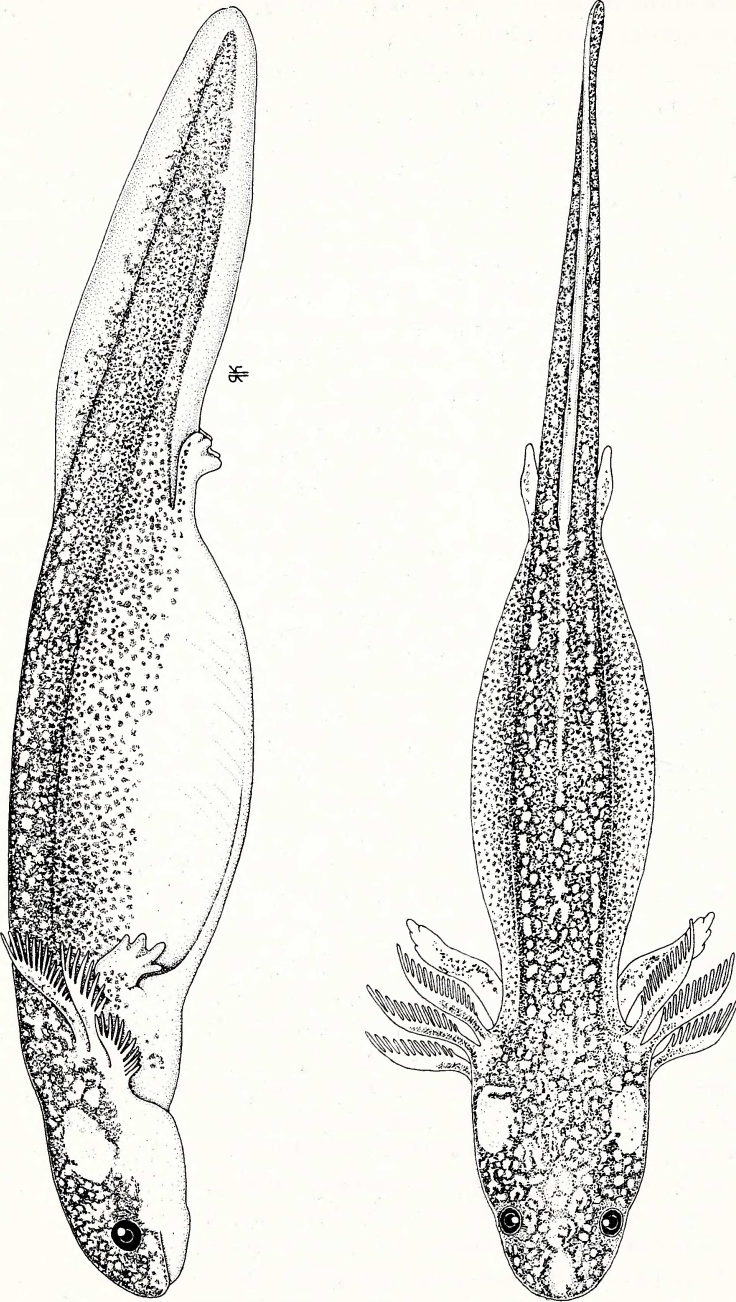


Fig. 1. Hatchling *Necturus lewisi* (NCSM 19827, lot); 20.7 mm TL (in preservative).

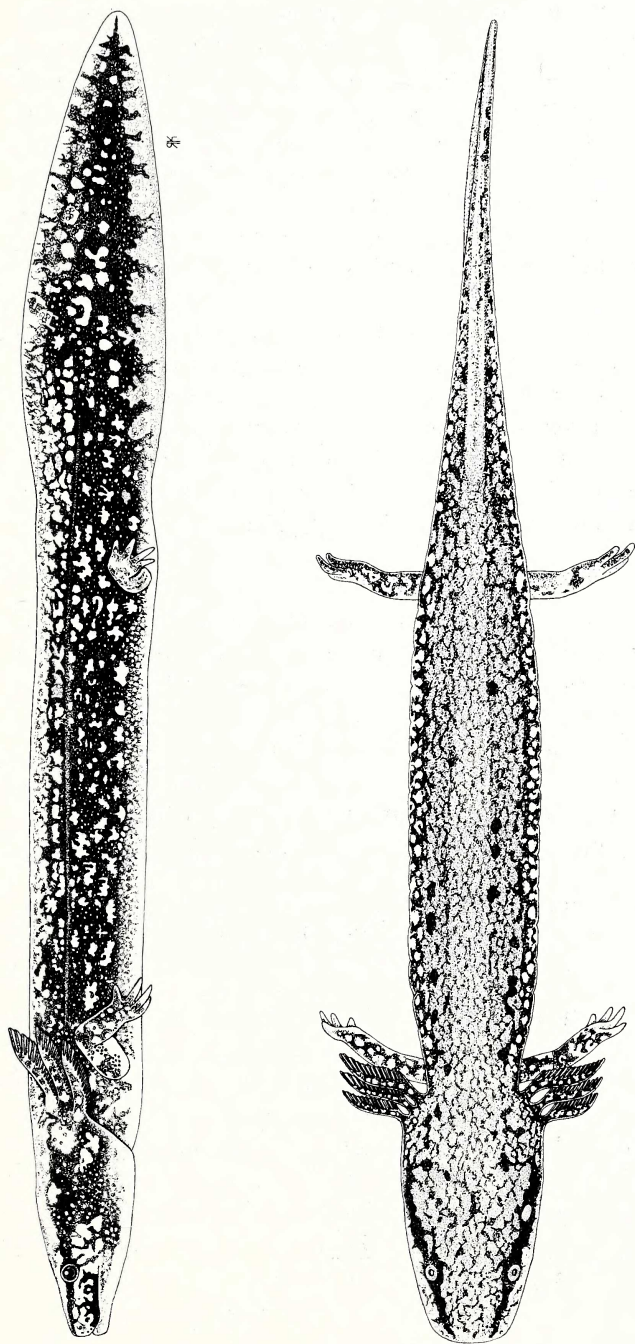


Fig. 2. Post-hatchling (striped) larva of *Necturus lewisi* (NCSM 16555); 42 mm SV, 65 mm TL (in preservative).

(Fig. 2). These larvae also have a broad, light tan, dorsal stripe which edges the costal grooves and extends from the snout onto the dorsum of the tail and across its width. The dorsal region may have a scattering of small, poorly defined, dark spots. The dark lateral stripe is continuous from the nostrils through the eye and labial region to the tail where it widens and includes all but the tail fringes. Irregular light blotches which lack melanophores are scattered throughout the costal and tail region. Most of the tail fin is lightly pigmented, but its edges lack pigmentation, as does the tip of the tail. The underside is white or has a faint, reticulated pattern.

A larva, maintained alive for one year, measured approximately 30 mm SV at capture and had a striped pattern which changed when it reached 45 mm SV. The lateral melanophores decreased in intensity while the dorsal spots became darker and better defined. Sixty-three percent of the preserved specimens ($N = 33$) between 45 and 72 mm SV show a similar loss of striped pattern with a distinct increase in dorsal spotting. All animals over 63 mm SV have an adult dorsal pattern.

DISCUSSION

The *N. lewisi* nest resembled reported stream nests of other *Necturus* species in construction, location, and general conditions. The number of eggs was greater than the 15 to 20 reported by Bishop (1943) for stream nests of *N. maculosus*, but within the range of 22 to 49 reported by Shoop (1965) for *N. m. louisianensis*.

Although Bishop (1943) and others verified females near or attending nests, few adults actually have been found in this situation. Most observers appear only to have surmised that nests are attended by females. Our

TABLE 1. Measurements (mm) of 7 newly hatched *Necturus lewisi* (NCSM 19827, lot). SV = snout-vent length; TL = total length; TW = tail width; HL = head length; HW = head width.

SV	TL	TW	HL	HW
15.3	22.8	3.0	3.5	3.0
15.5	23.6	3.2	3.7	3.0
16.3	23.0	2.9	*	*
15.5	23.1	3.0	3.5	3.1
15.0	22.2	3.0	3.5	3.0
15.9	23.4	2.0	3.5	3.1
<u>14.9</u>	<u>21.8</u>	<u>3.1</u>	<u>3.6</u>	<u>3.0</u>
$\bar{x} =$ 15.4	22.8	3.0	3.5	3.0

*damaged in capture

deduction that the male present in the nest was attending it and not preying on hatchlings is based on the absence of larvae from the digestive tract and the reluctance of the male to leave the nest. Broader studies which we are now conducting on *N. lewisi* may provide evidence to corroborate this observation.

Brimley (1924) stated, "Young specimens of the northern form (*N. maculosus*) are said to be striped with black, but the smallest of ours that I have seen (measuring only about 3 ½ inches in length) was spotted exactly like larger specimens. In view of these facts it would seem fairly apparent that the dwarf form occurring at Raleigh is a geographical variant of subspecies of the true *maculosus*, and I propose for it the name *Necturus maculosus lewisi* . . ." A similar description of the larva was given by Hecht (1958). Viosca (1937) elevated *N. m. lewisi* to full species status and stated that 55 mm larvae were dark on the sides and had a light dorsum marked with faint spots. He also indicated that these spots develop into two or three irregular rows as the larvae approach 90 mm, at which length all striping disappears and they attain the adult spotted appearance. We assume that Viosca's measurements were total lengths, although this was not indicated. If so, his observations compare favorably with ours of live and preserved post-hatchling larvae, confirming that such larvae are quite distinct from those of *N. maculosus* as illustrated by Bishop (1943), and *N. m. louisianensis* as described by Shoop (1965).

The major difference is that *N. maculosus* post-hatchling larvae have a dark dorsum bordered on each side by a thin, light, dorsolateral stripe. However, newly hatched larvae of both species are indistinguishable from each other. The larvae of *Necturus punctatus*, a species largely sympatric with *N. lewisi* although occupying a broader range, are uniformly gray in color with no evident striping (Brimley 1925, Bishop 1943). The distinctive post-hatchling larva of *N. lewisi* lends added credence to its current recognition as a full species.

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LITERATURE CITED

- Barbour, Roger W., J.W. Hardin, J.P. Shafer, and M.J. Harvey. 1969. Home range, movements, and activity of the dusky salamander, *Desmognathus fuscus*. *Copeia* 1969(2):273-297.
- Bishop, S.C. 1926. Notes on the habits and development of the mudpuppy, *Necturus maculosus* (Rafinesque). N.Y. State Mus. Bull. 268:5-60.
- Bishop, Sherman C. 1943. Handbook of Salamanders. Comstock, Ithaca. 555 pp.
- Brimley, C.S. 1924. The water dogs (*Necturus*) of North Carolina. J. Elisha Mitchell Sci. Soc. 40(3-4):166-168.
- Cahn, A.R., and W. Shumway. 1926. Color variation in larvae of *Necturus maculosus*. *Copeia* 1926(130):4-8.
- Fedak, Michael A. 1971. A comparative study of the life histories of *Necturus lewisi* Brimley and *Necturus punctatus* Gibbes (Caudata: Proteidae) in North Carolina. Master's thesis, Duke Univ., Durham. 103 pp.
- Hecht, Max K. 1958. A synopsis of the mud puppies of eastern North America. Proc. Staten Island Inst. Arts Sci. 21(1):1-38.
- Shoop, C. Robert. 1965. Aspects of reproduction in Louisiana *Necturus* populations. Am. Midl. Nat. 74:357-367.
- Viosca, Percy, Jr. 1937. A tentative revision of the genus *Necturus*, with descriptions of three new species from the southern Gulf drainage area. *Copeia* 1937(2):120-138.

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